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I, JANENE PEISKER, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2004900556 for a patent by PHILLIP JAMES as filed on 06 February 2004.



WITNESS my hand this
Second day of March 2005

A handwritten signature in black ink, appearing to read "J.K.P.C." or a similar variation.

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AUSTRALIA
[Patents Act 1990]

Provisional specification
Standard patent

LEANING VEHICLE

The invention is described in the following
statement • • 7 pages description.
4 pages drawings.

LEANING VEHICLE

Background of the invention

This invention relates to the field of narrow leaning vehicles. Vehicles with narrow dimensions are the vehicles of the future if the over use of natural resources is to be reduced. A narrow vehicle is required to lean into a corner and so the means to control such a vehicle has been the subject of much debate and research. This present invention describes a simple and safe method to achieve a narrow leaning vehicle which is easy to control by anyone familiar with conventional vehicle control, and which displays exceptional agility and steering performance.

Description of the Invention

The initial description is of a leaning vehicle with 2 front wheels. In FIG 1 is shown the front end of a leaning vehicle with 2 laterally spaced front wheels [not shown], located on a parallelogram linkage common in the art. Lever arms [1,1a] extend forward from the 2 wheel uprights[2,2a] and are connected by a track rod [3] which maintains the wheels in the desired alignment. There is no other restraint on the front wheel set, the front wheel set is free to caster. As will be described later, the vehicle is provided with a means to force it to lean due to driver input on the control, and because of the parallelogram linkage. When the vehicle leans the wheels also lean, but the amount that the wheels lean relative to the amount that the vehicle leans may be varied as desired.. It is common in the art that that a single rear wheel is attached to the vehicle structure to lean with the vehicle structure as is the case in a normal motorcycle, but this may be varied and 2 rear wheels may be used which either lean with the vehicle structure or remain upright and allow the vehicle to lean by providing a pivot around which the majority of the vehicle can lean. These variations are well known in the prior art. No matter what the rear wheel arrangement, the vehicle being described has 2 front wheels arranged to operate on a trail [4] so providing a castering action . The trail is provided by arranging the geometry so that the tyre contact patch is rearward of the point where an extension of the king pin axis would strike the road surface. When the vehicle is leaned the front wheels also lean and this causes the front wheels to turn into the direction of the lean due to gyroscopic action and caster induced lean, commonly referred to as "steering weight effect". Other dynamic reactions may contribute to the process. The front wheels being free to caster, will take up a steer angle which will produce a steered vehicle path which is fundamentally

suitable for the lean angle of the vehicle and the speed of the vehicle. The vehicle will be fundamentally balanced at all times. As mentioned, the vehicle is arranged to lean under command from the driver using a control[preferably a steering wheel]. This control is operated in a "simple steer" manner, that is the direction of movement relates directly in sense to the direction of lean of the vehicle and so, the direction of steer of the vehicle. In FIG 1 is shown a driver control [5], steering shaft [6] and gear set [7]. In the gear set, one gear is connected to the upper parallelogram cross arm [8] and the other to the steering shaft. This gear set can be replaced by a more conventional steering box which provides a connection between driver input and vehicle lean. The fundamental principle is that a torque or displacement applied to the control applies a mechanical torque or displacement to lean the vehicle. Also shown are 2 servo valves [10,10a] in series fitted to the steering shaft [6]. These servo valves are similar in all respects to a normal power steer servo valve, and incorporate a torque reaction spring [not shown] which regulates the valve opening as a function of driver applied torque on the control. These servo valves are provided with independent power sources , each valve is connected to its own hydraulic pump [11,11a] and each servo valve directs fluid to its own double acting hydraulic actuator [12,12a] The power system however , may be

5 hydraulic, electric or pneumatic with appropriate valves and actuators. It is understood that the nature of the power supply and its origin may be varied between one style and the other. A hydraulic pump engine driven, and an electric system operating off the vehicle battery, or an arrangement where

10 one pump is engine driven and the other driven off the vehicle transmission as desired. The position of the actuators, the nature of the driver connection to vehicle lean, the pump arrangements and the style of the servo valves may be varied as long as the basic function is adhered to.

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Basic function of the system.

As the driver makes an input on the control to steer the vehicle, he applies a torque to lean the vehicle in the direction that the driver wishes the vehicle to steer. Driver input torque is initially resisted by the inertia of the vehicle mass which causes the servo valves to deflect against their springs. This causes the servo valves to direct fluid to their actuators[hydraulic system being described], which causes the vehicle to

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lean in the required direction. As the vehicle leans the wheels steer as previously described, which translates to a displacement of the control as a function of vehicle lean [and steer]. When the driver observes that the steered path of the

5 vehicle is to his needs he ceases to urge the control. In this process the initial torque to overcome vehicle inertia is replaced by a steady state torque provided by the steering geometry of the castering wheels which always tend to return the vehicle to vertical. This steady state torque can be varied

10 by artificial means eg. spring loading of the vehicle to vertical or spring loading of the roadwheels by a sprung link to the vehicle structure which causes the wheels to be displaced slightly off their natural free to caster position. If the wheels are displaced to turn in more than they would if left to caster

15 free, then a torque will be applied to return the vehicle to vertical due to the fact that the wheels are countersteering the vehicle against the power being applied to lean it. In this way the "feel" of the vehicle can be adjusted as required to produce the desired steering loading on the control in all

20 conditions of vehicle control.

Sub Systems

In FIG2 is shown a method to spring load the vehicle to vertical, In FIG2 is shown a section of the lower parallelogram cross arm [13] which pivots on its axis [16]. A lever arm [17] is attached to the centre of the crossarm and extends vertically and has a slot provided in which an axle for a roller [18] is located. The slot in this lever is purely to provide an adjustment for the height of the roller above the lower crossarm pivot axis, and is locked in position by nut and washer[19]. The roller runs in a slotted lever[20] which has its pivot axis [21] located in an extension of the vehicle structure [22] and this slotted lever is free to turn in a bush provided in the vehicle structure extension. Springs [23,23a] are

attached to lugs on the slotted lever at one end and the springs are tensioned as desired and their other ends attached to the vehicle structure [not shown]. In this way a variable rate of spring loading to vertical or otherwise, for the vehicle is

5 provided and a quick adjustment is also available by altering the locked position of the roller axle and the spring tension. The result is a variable relationship between lean angle and spring loading of the lean to vertical, such relationship being tailored to suit vehicle requirements

10 In fig 3 is shown a method of spring loading the vehicle wheels so that as the vehicle leans the wheels are turned into the direction of lean more than they would if they were left to be totally free to caster. In this arrangement the resilient connections [14] which are shown as rubber cords or springs, are attached at one end to the vehicle structure [9] and

15 at the other end to vehicle steer levers [15] FIG3b. the attachment on the vehicle structure is below the point of attachment to the wheel steer levers so that when the vehicle parallelogram leans[FIG3a] the rubber cords apply a torque to influence the position that the wheels take up. By altering the height of the

20 vehicle structure attachment points relative to the height of the attachment points on the wheel steer levers, and by varying the strength of the spring loadings, various effects can be achieved to tune the vehicle characteristics , as previously mentioned.

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Power System.

As described the vehicle has 2 separate power systems. This is arranged so that a failure of one system will not threaten the easy control of the vehicle. In normal operation the 2 systems share the responsibilities of providing power to lean the vehicle. The 2 servo valves deflect equally and the 2 actuators work in unison. If a failure occurs in one system the remaining system can easily control the vehicle. However , because the operational servo valve will require a greater deflection to achieve the power required, the driver will be

30 aware of a system failure and such awareness can be reinforced by additional warning methods.

Slow speed control.

At speeds above approx 7 MPH the vehicle has a very strong relationship between lean action and steer action, there being no observable delay between the lean action and the steer action of the wheels. However, below approx. 7MPH this strong bond breaks down and additional mechanisms are required to provide sharp steering response. With reference to FIG4 it is now described a method to enable sharp steer response below 7MPH in a vehicle with 2 front wheels In FIG4 is shown a representation of the parallelogram linkage of the vehicle. The resilient rubber cord [14] previously referred to in FIG 3 is attached to the body of an actuator [24] The actuator body is arranged to run on the actuator shaft which is attached to the vehicle structure [9]. The movement of the actuator is provided by a position control system which operates as a function of vehicle speeds of 0 to 7mph[approx] Also shown in FIG4 is a non resilient flexible cord which is shown hanging in a curve depicting the fact that it is not in tension [25] In FIG4a the actuator body is shown fully down which has resulted in the cord[25] being brought into tension and so creating a direct mechanical link between the vehicle lean and the vehicle steer due to the fact that the cord[25] is attached ~~is attached~~ to the vehicle steer levers[as is the resilient cord [14] as was depicted in FIG3b. This creates a fixed lean steer ratio at dead slow speed, which is progressively removed by raising the actuator body as speed increases, thus releasing the tension on cord [25] and varying the spring loading on resilient cord [14]. In this way is described a method to overcome the natural tendency for a free to caster wheel set to loose its tight relationship with vehicle lean below approx 7mph. It should be understood that a failure of this process will not render the vehicle unsafe and that any failure must be arranged so that the system returns to the unactivated [actuator up] condition

Suspension with 2 laterally spaced wheels

Many leaning vehicles described in the prior art using a laterally spaced wheel set, create undesirable reactions when the vehicle is leaning and the wheels experience a suspension movement in bump or rebound. Many suspensions in the prior art are based on a double wishbone arrangement, each wishbone set pivoting off an axis on the vehicle centre line. The wishbones then form the fundamental leaning linkage[parallelogram] plus they allow additional movement for suspension. This results in the tyres being forced to scrub across the road surface when a bump or rebound action takes place while the vehicle is leaning. A conventional motorcycle on the other hand has no such reaction and the tyres follow the "natural rolling path" when moving over a bump or into a hollow in the road surface even when the vehicle is at maximum lean angle. This is because in a motorcycle the wheel moves in suspension in the same plane as its inclination. To allow the wheels of a laterally spaced wheel set to behave as does the wheel on a motorcycle[or near so] the following description of a leaning vehicle suspension is given with reference to FIG5. The upper and lower cross arms[8,13] of the parallelogram linkage are one piece items each pivoting off their centres [26] on axles located on the vehicle structure. Each cross arm has ball joints fitted to their ends which attach to the closed fork uprights[27,27a] which allows the parallelogram to lean and the uprights to turn in steering. The stub axles [28,28a]are fitted to axle carriers [29,29a] which run on the parallel bars which form part of the uprights. The lever arms[1,1a] which connect the 2 wheels in alignment via track rod[3] are mounted on the uprights [27,27a]and so the wheels move in suspension while the steer levers and track rod do not move. This arrangement prevents any form of bump steer occurring at any angle of vehicle lean and the arrangement also causes the vehicle

wheels to move in the same plane as their inclination, when the wheels move in suspension at any angle of vehicle lean and so, the vehicle tyres follow the natural rolling path at all times over bumps or hollows in the road surface.. The lean action, and the suspension action are separate. The suspension springs can be located as desired but are shown in this example located on pads, one pad on the wheel upright[27] and the other on the wheel carrier [29].

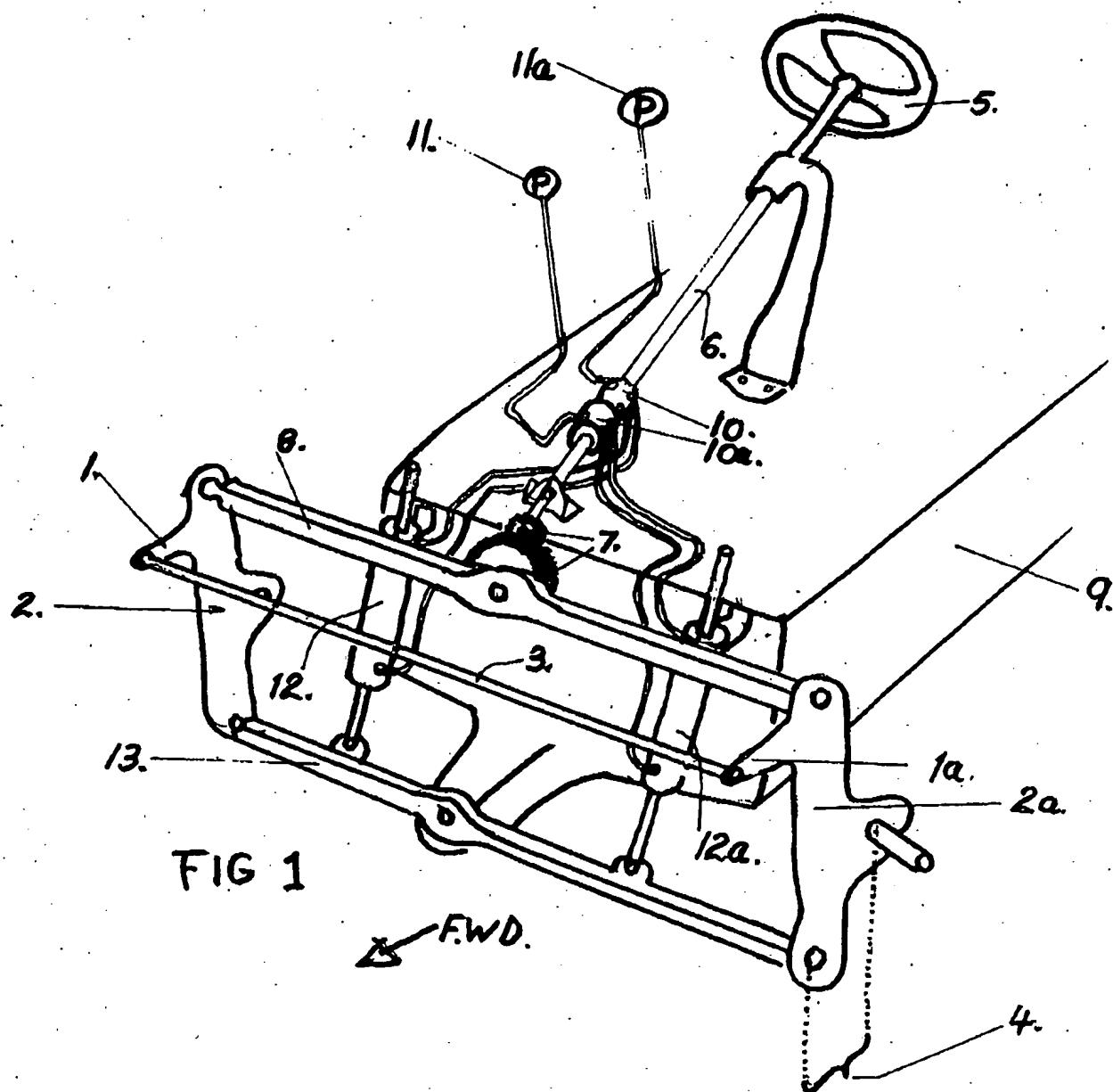
Vehicle Variations.

- 10 Now it will be clear to those skilled in the art that it matters not whether the castering front end comprises 2 wheels joined in a set or 1 wheel arranged to be attached to the vehicle structure in a similar way that the front wheel of a motorcycle is attached. In a vehicle which uses a single front
- 15 wheel, the front wheel is allowed to be free to caster under the identical influences that have been described in relation to 2 front wheels. Again, in the 1 front wheel vehicle the driver input is directed in an identical way [in principle] to lean the vehicle except that in this case the attachments between
- 20 vehicle structure and rear wheel laterally spaced structure provide the means to lean the vehicle It is clear that the principle of leaning the vehicle by applying a force between the vehicle structure and the wheel set rely on the requirement that the wheel set be laterally spaced. the spacing of a wheel set laterally whether front or rear, is a fundamental requirement. Another fundamental requirement which has been outlined in this invention is a free to caster wheel or wheel set. Another fundamental requirement is the provision of a power source controlled by a servo valve or 2 servo valves under the
- 25 influence of driver input, and the servo valve or valves being placed between driver input and vehicle lean. The fundamental operation of the system which has been described can be applied to various vehicle arrangements as long as the principles outlined are provided for.
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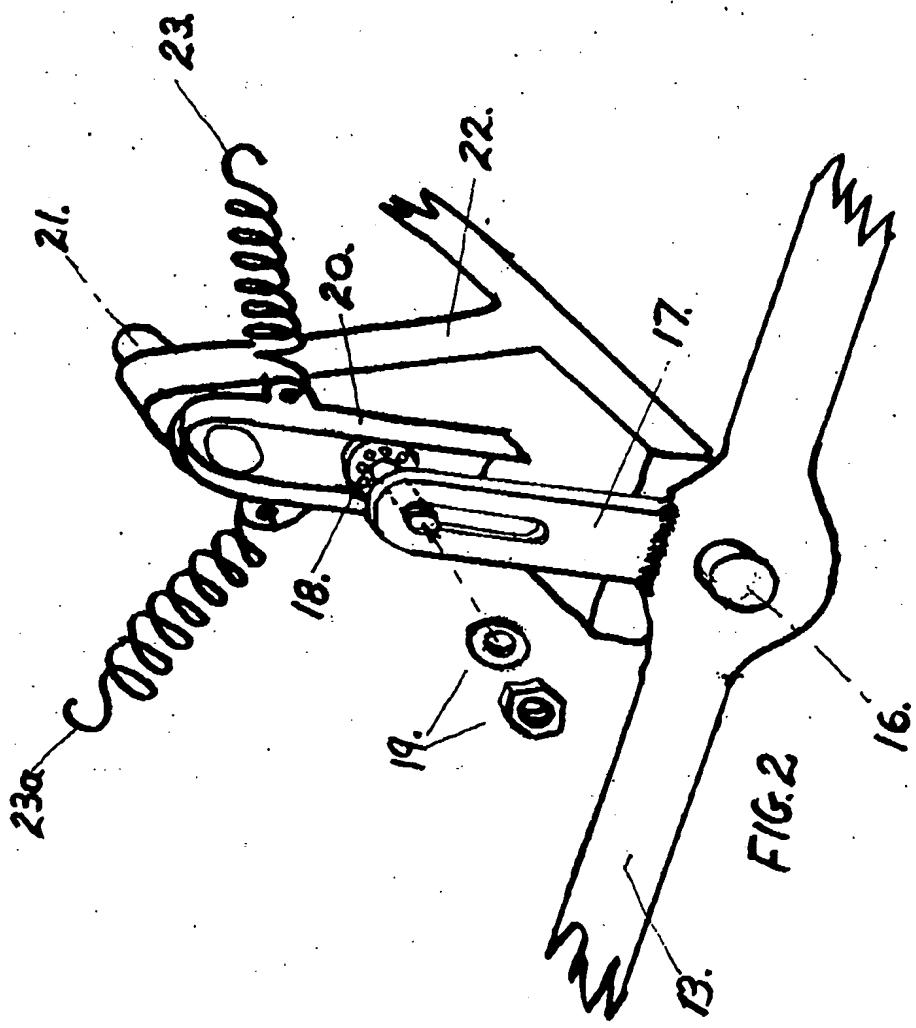
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Dated 4th Feb 2004

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FIG 4.

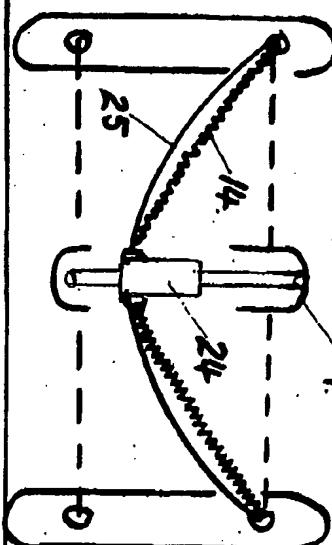


FIG 4a.

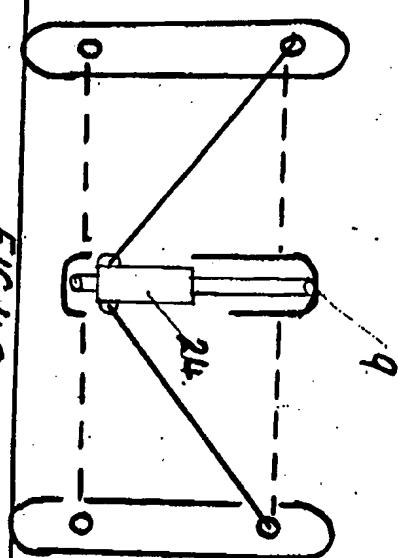


FIG 3.

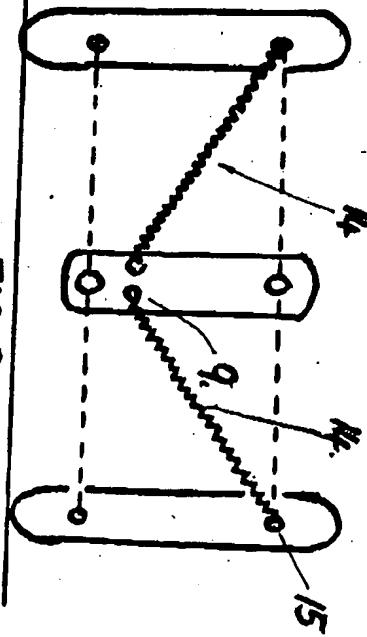
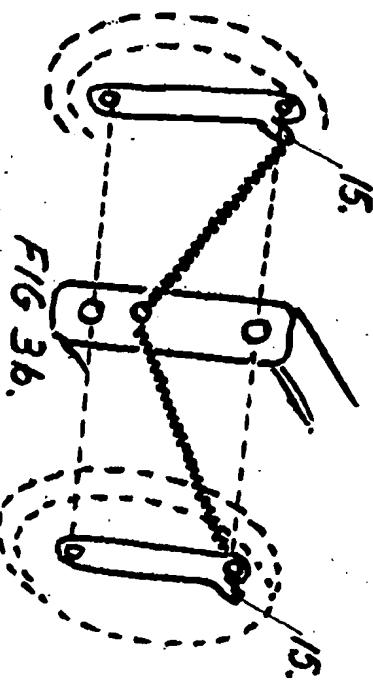
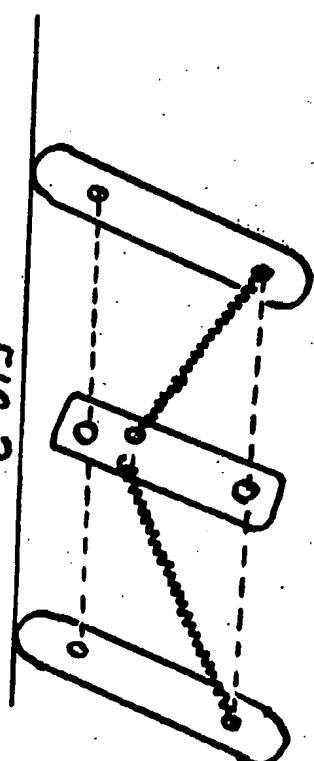


FIG 3a.



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